Evidence builds for Planet Nine lurking somewhere out there

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The hypothesized Planet Nine is a distant, massive planet in our solar system. Credit: NASA

Recent papers by Michael Brown and Konstantin Batygin, both astronomers at Caltech, are providing a whole new line of evidence in support of the existence of our solar system's hypothesized Planet Nine.

First evidence

This distant, massive world was first predicted in 2014 by astronomers who noted the unusual orbits of various outer solar system bodies called extreme trans-Neptunian objects. Trans-Neptunian objects (TNOs) have orbits that are farther from the Sun than Neptune. Extreme TNOs, or ETNOs, have even more elongated, distant orbits that are unaffected by interactions with any of the known planets. The dwarf planet Sedna, discovered in late 2003, was the first known ETNO.

Following Sedna's discovery was speculation that its odd orbit must imply the existence — and influence of — of some large unknown planet or perhaps a nearby passing star. Then, the discovery of the second ETNO in 2014 strongly pointed the finger toward an unknown planet as the likelier explanation, as described by astronomers Chad Trujillo and Scott Sheppard in a *Nature* paper. Meanwhile, other astronomers suggested that two large planets in orbital resonance with one

another would be necessary to explain the similarities of the orbits of these extreme objects, which are now classified as Sednoids.

In 2016, Batygin and Brown first outlined in detail how the orbits of six of these objects could be explained by a specific Planet Nine. They predicted this world must have a mass at least 10 times that of Earth, and an orbit some 400 to 800 times the distance between Earth to the Sun. That's some 13 to 26 times farther out than the orbit of Neptune, the outermost planet.

Now, Brown says, they've studied the orbits of 13 large ETNOs. And the clustering of some elements of their orbits "opened our eyes and made us say, 'what the heck is going on?'" Brown tells *Astronomy*.

Natural consequences

What's going on, he explains, is that they're seeing "not just clustering in the direction the orbits point, but also they are all tilted off the plane of the ecliptic [the plane of the solar system] by an average of about 15°. So both of these things together are pretty strange."

The researchers have seen similar clustering turned in the perihelia — the point of their closest approach to the Sun — of these distant objects that varies up and down, sometimes dipping close to Neptune's orbit, and sometimes swinging farther away. "That turns out to be another natural consequence of Planet Nine," Brown says. "We didn't think about it at the time when we first proposed the planet, it was not in our minds. But we quickly realized that was it."

Then, a third unexpected line of evidence emerged: a "very strange population of objects that no one had been able to explain," Brown says. They are objects whose orbits "are twisted by about 90° from the plane of the solar system and are on very eccentric orbits." These unusual orbits, he says, are "nearly impossible to explain without the existence of Planet Nine.

Now, in the latest results accepted for publication in *The Astronomical Journal Letters*, yet *another* line of evidence has emerged. It turns out there is yet another population of objects much closer to the Sun, between the orbits of Jupiter and Neptune, whose orbits also extend beyond Neptune.

Brown says these are likely objects that were originally part of a very distant population "that get captured into closer orbits and stick around for a long time." The team's analysis showed a smooth, gradual decline in the population of objects with perihelia closer to the Sun that Neptune, rather than the sharp cutoff just inside Neptune's orbit that would occur without the influence of Planet Nine's gravitational pull. "I can't think of any other explanation that could possibly give that result," he says.

In a separate paper, Brown, Batygin, and Matthew Holman of the Center for Astrophysics | Harvard & Smithsonian describe their detailed search of the regions of the sky where Planet Nine is expected to lie, using the vast database of images from the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) on Haleakala, Maui. This search, combined with previous searches using other databases and the team's own observations, has now ruled out the planet's presence from 78 percent of the predicted region.

The Vera C. Rubin Observatory's survey of the southern sky will produce about 20 terabytes of raw data every night. NOIRLab/NSF/AURA

New tools

But there is new hope. Next year, the Vera C. Rubin Observatory will come online in Chile, scanning the entire southern sky every four days with the largest camera ever built. The team's analysis says there is a very high probability that if Planet Nine exists, the Rubin system should be able to find it within a year or two, proving its existence once and for all.

"What's great about this," says Thomas Levenson, a professor of science journalism at MIT and author of *The Hunt for Vulcan* (Random House, 2015), "is that since the initial proposal, they've increasingly refined that prediction. They've used further observations of additional groups of these objects to make the prediction more explicit, more precise, and thus more falsifiable."

He adds that "this is the way science is supposed to work, and it very often doesn't work this way." And as a fan of astronomy, he says, "what's exciting is they hold out the prospect that this is testable in an ordinary human lifespan… With the right observatory, we can see things that will help us confirm or deny, and that observatory is almost at hand, it's just set to go, and that's very exciting."

"I think the chances are good," Brown says. But a detection "relies on the observatory choosing to push further into the Northern Hemisphere than the nominal plan has it doing," a chance that has yet to be decided. And it also depends on Planet Nine not being "on the extreme far ends of its possibilities" in terms of location and distance.

“It could be farther away than our initial predictions, and in that case, [the Rubin Observatory] will not be able to track it down either, and I’ll be depressed,” Brown says. But he adds that “if Planet Nine is not out there, we need a separate explanation for each of these other things, that can all be explained by a single Planet Nine. So it’s a very elegant solution to a lot of different problems, which is a good sign that it’s probably there.”

“Until there’s a better explanation for all these phenomena, I still think Planet Nine is probably real,” he says.